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Research Article

Effect of Potassium Sulphate Fertilizer Doses on Sugarcane Growth Yield and Quality Grown in Sudan

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Abstract: Sugarcane is one of the most important crops in Sudan which played a leading role in the local and foreign trade. Research has been conducted in two sites in Sugarcane Research Center Farm in Guneid-Sudan from 5/7/2019 to 5/9/2020. The study aimed to evaluate the effect of potassium sulphate fertilizer doses on the growth, yield, and quality of sugarcane. The variety tested was Co 6806. The treatments consist of five doses of potassium sulphate (SOP) fertilizer which contains (50% K_2O and 18% S); K1: 0.0, K2: 40, K3: 80, K4: 120, and K5: 160 kg SOP kg ha^{-1} arranged in a randomized complete block design (RCBD) replicated three times. The results obtained showed that there was a significant effect on plant growth due to the application of different levels of potassium sulphate fertilizer in the two sites. Statistically, the treatment K3: (80 SOP kg ha^{-1}) significantly recorded the highest cane and sugar yield values compared to the other potassium sulphate levels and the control in the two different experimental sites.

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1. Introduction

Sugarcane (*Saccharum officinarum* L.) is a perennial grass belonging to the genus Saccharum, family Poaceae, and tribe Andropogoneae, according to Kolo et al. (2005). Approximately 79% of the world's sugar is produced from sugar cane, while sugar beet represents about 21% of global sugar production. All sugarcane schemes in Sudan lie in the central clay plain soils, which soils have a few limitations. Fertilization with the major elements of nitrogen, phosphorous and potassium is a necessary agricultural practice, and the cultivated plants need greatly. It also has direct effects on both vegetative growth and fruit growth and clearly affects the quantity and quality of fruits (Toprak, et al. 2021). The main characteristics of the central clay plain soils are high clay content, alkaline pH, low organic matter, and poor in both N and P nutrients. Dawelbeit (2010) recorded a deficiency of potassium in some parts of the central clay plain soils in Sudan. Sugarcane, as a long-duration, labor-intensive crop, removes a significantly greater amount of plant nutrients from the soil. Jagtap et al. (2006) reported that sugarcane production of 100 tons per hectare removes 207 kg N, 30 kg P_2O_5, and 233 kg K_2O from the soil. Hence, it is essential to replenish the depleted soil with plant nutrients at the desired levels. Potassium (K) is commonly called potash, which is defined as K_2O. Potassium is the most absorbed nutrient by the sugarcane crop, and it plays various metabolic functions in plants, including photosynthesis, protein synthesis, the activation of several enzymes, and the functioning of the stomata (Hawkesford et al., 2012). The main sources of potassium were muriate of potash (MOP) and sulfate of potash (SOP). In tropical soils, usually with scarce K availability, fertilization with K nutrient should induce positive responses in sugarcane since K is the nutrient most extracted by agriculture (Korndorfer and Oliveira, 2005). Low levels of available K in the soil contribute to reduced sugarcane longevity. Therefore, it is considered an important element in restoring the productivity of sugarcane. There is a general understanding that the central clay plain soils in which all sugarcane schemes lie are rich in K and that there is no need to add potassium to the soil based on a few research studies. El-Tilib et al. (2004) reported that fertilization of cane fields in Sudan was geared towards using nitrogen and phosphorus to a small extent. Kwong and Pasricha (2002) reported that potassium is a relatively expensive nutrient, and deficiencies can often be corrected with a moderate rate of application, which can result in excellent economic returns. Many factors are responsible for the decline in sugarcane yield. Among these factors is the unbalanced nutrition of sugarcane with NPK fertilization. Therefore, the main objective of this study was to evaluate the effect of different levels of potassium sulfate fertilizer on the growth of sugarcane plants.

2. Material and Methods

From 5/7/2019 to 5/9/2020, the research was conducted at two sites in the Sugarcane Research Center Farm in the Guneid area (33o 19″ E, 14o 47″ N). The soil of the experimental site was classified as the Suleimi soil series, which is clayey Smectitic alluvium and clayey vertisol with moderate chemical fertility. The variety tested was Co 6806. Potassium sulphate (SOP) fertilizer, which contains (50% K_2O and 18% S), was distributed evenly to the experimental units using the broadcasting application method. The experimental design was a Randomized Complete Block Design (RCBD). The treatments included five levels of potassium sulphate fertilizer K1:0.0, K2:40, K3: 80, K4: 120, and K5: 160 kg ha^{-1} replicated three times. The time of application is 150 days after planting. The observation of growth parameters included:

1) Potassium concentration (mg/kg) from leaf sheath samples taken at 60, 90, 120, 270 and 360 days after planting. The samples were weighed and then oven dried and finely powered in a Willey Mill to pass through a 2 mm sieve, and potassium concentration were determined using the wet digestion method in which dilute acid (HN03: HCI04) was used with the help of a flame photometer (Tandon, 1998),

2) Plant height (cm), measured from soil surface to a first leaf joint,

3) Stalk diameters were measured from the middle of the sample stalk,

4) The number of millable stalks per hectare,

5) Cane yield and quality parameters (the sugar cane juice quality parameters, which include sucrose percent (pol %), purity percent of cane juice, and sugar yield tons per hectare (tons/ha), were determined from juice analyzed according to ICUMSA (2007) methods of analysis)

Analysis of variance (ANOVA) was used to compare the different treatments, and the least significant difference (LSD) at the 5% level of significance was used to separate the means. (USDA, NRCS. March 2007, USA).

3. Results

3.1. Effect of potassium sulphate fertilizer levels on plant cane growth and yield parameters

Potassium concentration from the plant cane leaf sheath was determined at 60, 90, 120, 270, and 420 days after planting. The experimental results data in Figure 1 showed that potassium concentration in the plant cane leaf sheath starts with high K concentration values at 60 days of age and then decreases at 90 and 120 days after planting depending on the soil solution before the addition of different potassium sulphate fertilizer levels, which were added to the soil at 150 days from the planting date. Most of the potassium is absorbed in the canopy completion period or tillering, as confirmed to that by Medina et al. (2013), who found a higher concentration of potassium at the beginning of plant development and, over time, reaching a lower concentration in the adult plant at harvesting. After the addition of K_2SO_4 fertilizer levels at the exact time, K- concentration began to increase and then decrease with the increase of the crop age till it reached its lower K- concentration values at harvesting.

Regarding plant cane growth parameters, the experimental results from Table 1 showed that there was no significant difference in means between treatments due to the application of different potassium sulphate levels in all growth parameters; (plant height, number of tillers/$m^{2,}$ and number of internodes) in the two different experimental sites of the plant cane experiment.

Results in Table 2 showed that there was a significant difference between different potassium sulphate fertilizer levels in all cane yield parameters except for cane diameter. The treatment K3 recorded the highest cane length values (220.9 and 190.4 cm) in the two different experimental sites, respectively. The treatment K2 recorded cane length values of 195.7 and 185.9 cm in the two different experimental sites, respectively. The treatment K4 recorded cane length values of 187.0 and 177.9 cm in the two different experimental sites, respectively. The treatment K5 recorded cane length values of 192.6 and 170.5 cm in the two different experimental sites, respectively. The treatment K1: (the control) - recorded the lowest cane length values (185.2 and 183.1 cm) in the two different experimental sites, respectively. Experimental results data in Table 2 showed that there was a significant difference between different potassium sulphate levels in the number of millable stalks per hectare in the two different experimental sites. The treatment K3 recorded the highest number of millable stalks values (129.0 and 87.9), the treatment K2 recorded a number of millable stalks values of 109.0 and 84.5, the treatment K4 recorded a number of millable stalks values of 110.0 and 81.6), the treatment K5 recorded a number of millable stalks values of 115.0 and 82.4 in the two different experimental sites, respectively. The treatment K1 (the control) - recorded a number of millable stalks values of 114.0 and 78.4 in the two different experimental sites, respectively. Experimental results data in Table 1 also showed that there was a significant difference between different potassium sulphate levels on the cane yield in the two different experimental sites. The treatment K3 recorded the highest cane yield values of 95.2 and 99.5 tons of cane/ha, the treatment K2 recorded cane yield values of 76.6 and 84.7 tons of cane/ha, the treatment K4 recorded cane yield values of 80.4 and 89.4 tons of cane /ha, the treatment K5 recorded cane yield values of 84.1 and 89.5 tons of cane/ha in the two different experimental sites, respectively. In the two different experimental sites, the treatment K1 (the control) recorded cane yield values of 86.6 and 85.9 tons of cane/ha. Kadarwati (2020) concluded that 180 kg/ha of potassium in the form of K_2O increased sugarcane stalk diameter, weight, and yield. Ahmad et al., (2013) recommended 90 kg ha^{-1} to get a heavier stalk weight. The experimental results obtained from this study confirmed those of Kolln et al. (2013), who observed that increases in soil potassium content increased sugarcane productivity in Brazil. In addition, El-tilib et al. (2004) found that potassium application had a significant effect on plant density, stalk diameter, cane, and sugar yield. These results agree with Jafarnejadi (2013), Khan et al. (2005), and Kadarwati (2020), who found that optimum and balanced use of potassium fertilizers in different forms the improved cane yield and quality of different cultivars gave maximum economic benefit to the farmers.

3.2. Effect of potassium sulphate fertilizer levels on plant cane quality parameters

Experimental results data in Table 3 showed that there was a significant difference between different potassium sulphate levels on plant cane quality parameters, which include purity percent cane juice and sugar yield tons per hectare. In the two different experimental sites, there was no significant difference between different potassium sulfate levels on pol% and fiber% cane. Experimental data showed that there was a significant difference between different potassium sulphate levels in purity percentage of cane. In the two different experimental sites, the treatment K3 had the highest purity percent cane values (90.0 and 89.6%). In the two different experimental sites, treatments K4 and K5 recorded purity percent cane values (89.4 and 89.5%), while treatment K2 recorded purity percent cane values (87.7 and 88.4%). The treatment K1 (the control) recorded the lowest purity percent cane values of 84.6 and 86.6 in the two different experimental sites, respectively. Experimental results data in Table

3. showed that there was a significant difference between different potassium sulphate levels on sugar yield in the two different experimental sites. The treatment K3 recorded the highest sugar yield values (10.2 and 9.5 tons of sugar ha^{-1}) in the two different experimental sites, respectively. The treatment K4 recorded sugar yield values (9.6 and 9.4 tons of sugar ha^{-1}). The treatment K5 recorded sugar yield values (9.0 and 8.7 tons of sugar/ha), and the treatment K2 recorded sugar yield values (8.7 and 8.8 tons sugar ha^{-1}) in the two different experimental sites, respectively. The treatment K1 (the control)-recorded the lowest sugar yield values (8.4-and 8.3-tons of sugar ha^{-1}) in the two different experimental sites, respectively. According to the experimental results, potassium sulfate fertilizer application was effective in sugar formation and increased the percentage of sugar in the plant cane crop. The results obtained for cane quality characteristics are like those reported by Jafarnejadi (2013), who reported that applying potassium sulfate fertilizer at the appropriate dosage may improve cane quality and sugar yield. Also, the results of Phonde et al. (2005) confirmed that on crop quality, adequate potassium supply ensured a higher sugar yield. The results are also in agreement with that of Ng & Kwong (2002), who reported that the application of potassium sulfate fertilizer was the probable reason for the increase in sugar yield.

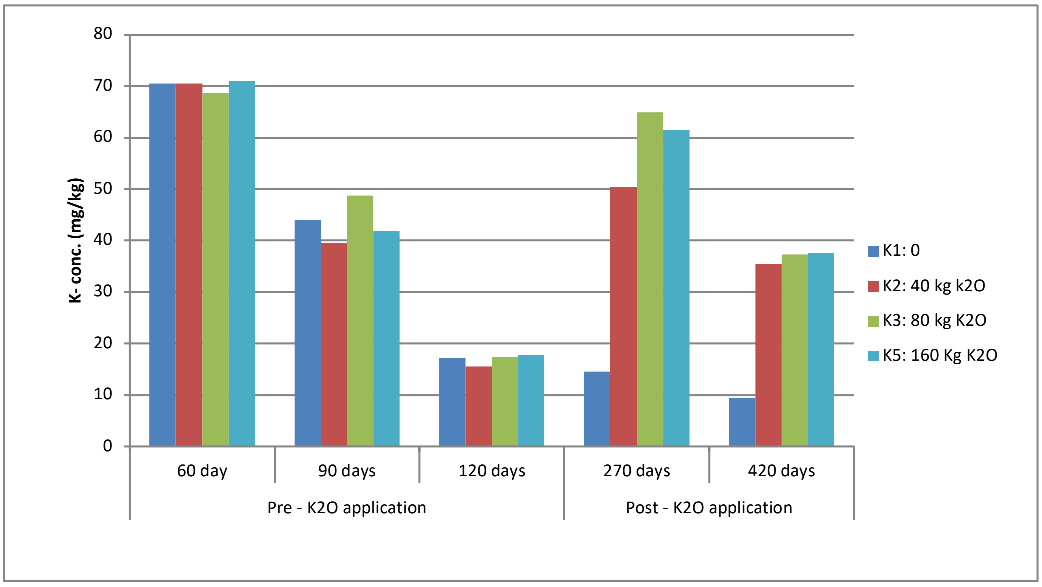

Figure 1. Potassium concentration (mg/kg) in plant cane leaf sheath.

Table 1. Effect of different potassium sulphate fertilizer levels* on plant cane growth parameters

Expt. Site	Treatments	Plant height (cm) 3 months age	6 months age	9 months age	No of tillers/m^2 3 months age	6 months age	9 months age	No of internodes 3 months Age	6 months Age	9 months Age
Site 1	K_1	44.0 a	66.8 a	172.8 a	10.5a	12.8a	15.5a	0.0 a	3.3a	11.0a
	K_2	39.0 a	67.5 a	175.3 a	10.3a	12.3a	14.8 a	0.0 a	3.0a	12.5a
	K_3	39.3 a	69.3 a	175.8 a	12.0 a	13.5 a	15.5 a	0.0a	3.5a	12.0a
	K_4	37.3 a	63.0 a	175.8 a	11.3 a	13.0 a	15.5 a	0.0a	2.8a	12.8a
	K_5	35.0 a	66.0 a	168.3 a	11.8a	13.5a	15.8 a	0.0a	3.0a	11.0a
	Mean	38.9	66.5	173.6	11.2	13.0	15.4	0.0	3.1	12.2
	CV%	17.00	13.4	2.84	12.1	10.20	4.78	0.0	4.3	10.6
	LSD (0.05)	10.2	13.7	7.6	2.1	2.0	1.1	0.0	1.4	2.0
Site 2	K1	42.3a	71.8a	179.3a	9.5a	13.0a	15.5a	0.0a	3.8a	9.8a
	K2	42.8a	73.3a	184.0a	9.3a	12.0a	15.5a	0.0a	3.5a	9.8a
	K3	47.5a	74.8a	185.3a	10.3a	12.8a	15.3 a	0.0a	3.8a	10.0a
	K4	43.0a	68.5a	184.3a	9.8a	12.3a	15.3a	0.0a	3.5a	10.3a
	K5	38.0a	71.5a	180.0a	9.0a	12.0a	15.3a	0.0a	3.5a	10.5a
	Mean	42.7	72.0	182.0	9.6	12.4	15.3	0.0	3.6	10.7
	CV%	12.3	12.7	2.6	11.4	7.5	5.3	0.0	2.8	11.3
	LSD (0.05)	8.1	14.1	7.2	1.7	1.4	1.2	0.0	1.2	1.9

*Five levels of potassium sulphate fertilizer K1:0.0, K2:40, K3: 80, K4: 120 and K5: 160 kg ha^{-1}.

Table 2. Effect of different potassium sulphate fertilizer levels* on plant cane yield parameters

Treatments	Cane length (cm)		Cane diameter (cm)		Number of millable stalks\hectares		Cane yield (Tons per hectare)	
	Site1	Site2	Site1	Site2	Site1	Site2	Site1	Site2
K_1	185.2^{b}	183.1^{ab}	2.0^{a}	2.0^{a}	114.0^{b}	78.4^{b}	86.6^{ab}	85.9^{b}
K_2	195.7^{b}	185.9^{ab}	2.1^{a}	2.0^{a}	109.0^{b}	84.5^{ab}	76.6^{ab}	88.7^{ab}
K_3	220.9^{a}	190.4^{a}	2.1^{a}	2.1^{a}	129.0^{a}	87.9^{a}	95.2^{a}	99.5^{a}
K_4	187.0^{b}	177.9^{bc}	2.0^{a}	2.1^{a}	110.0^{b}	81.6^{ab}	80.4^{bc}	89.4^{ab}
K_5	192.6^{b}	170.5^{c}	2.0^{a}	2.0^{a}	115.0^{b}	82.4^{ab}	84.1^{bc}	89.5^{ab}
Mean	184.4	181.6	2.1	2.0	115.0	83.0	84.0	92.6
CV%	8.5	6.3	3.3	5.1	8.4	12.1	8.5	12.8
LSD(P<0.05)	18.7	12.2	0.2	0.2	12	9.3	8.8	12.6

*Five levels of potassium sulphate fertilizer K1:0.0, K2:40, K3: 80, K4: 120 and K5: 160 kg ha^{-1}.

Table 3. Effect of different potassium sulphate levels* on plant cane quality

Treatments	Pol % cane Juice		Purity % cane Juice		Fiber % cane		Sugar yield Tons per hectare	
	Site1	Site2	Site1	Site2	Site1	Site2	Site1	Site2
K_1	12.8^{a}	11.6^{a}	84.6^{d}	86.7^{b}	18.6^{a}	18.5^{a}	8.4^{c}	8.3^{b}
K_2	12.6^{a}	11.8^{a}	87.7^{cd}	88.4^{a}	18.4^{a}	18.5^{a}	8.7^{c}	8.8^{ab}
K_3	12.7^{a}	12.1^{a}	90.0^{a}	89.6^{a}	18.9^{a}	18.6^{a}	10.2^{a}	9.5^{a}
K_4	12.8^{a}	11.7^{a}	89.4^{ab}	89.5^{a}	18.1^{a}	18.3^{a}	9.6^{b}	9.4^{a}
K_5	12.7^{a}	11.7^{a}	88.9^{bc}	88.4^{ab}	18.4^{a}	18.2^{a}	9.0^{bc}	8.7^{ab}
Mean	12.7	11.7	88.7	88.6	18.4	18.4	9.2	8.9
CV%	3.9	3.4	1.6	2.0	4.2	4.6	10.8	12.4
LSD (P< 0.05)	0.6	0.8	0.5	1.8	0.8	0.9	1.1	1.2

*Five levels of potassium sulphate fertilizer K1:0.0, K2:40, K3: 80, K4: 120 and K5: 160 kg ha^{-1}.

Conclusion

For the cultivation of sugarcane in Guneid-Sudan, application of different levels of potassium sulphate fertilizer resulted in a significant effect on plant growth, and the treatment K3 (80 SOP kg ha-1) recorded the highest cane and sugarcane value in terms of yield and yield quality.

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